

Hydrological Modelling of Land Use and Climate Change Impact for Water Management in Twinned River Basins

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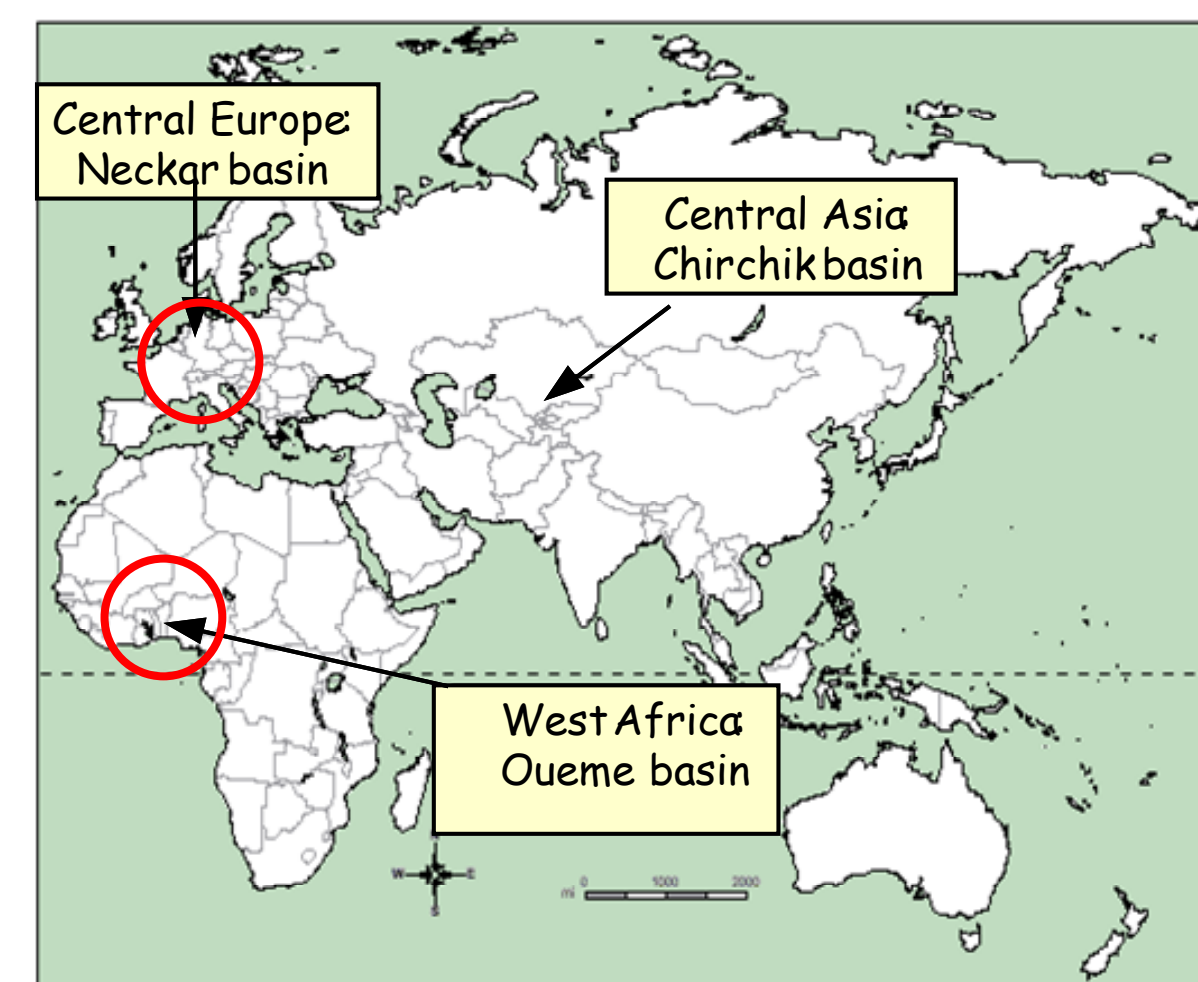


Fig. 1: Location of the project basins

Abstract: The project “RIVERTWIN” developed an integrated regional model for the strategic planning of water resources management in twinned river basins. The model simulates the impacts of climate and land use changes on the availability and quality of water resources. It was developed in the European Neckar basin with high data density, transferability to regions with low data availability was tested in the Ouémé basin in Benin. In cooperation with stakeholders, scenarios of land use and climate change were developed and the implications for integrated water resources management under the respective assumptions were assessed. As an example, the results of two climate and land use change scenarios for the Ouémé basin are presented.

1. The integrated regional model:

- links hydrologic, ecologic and economic models
- provides indicators for river basin management plans

2. The distributed HBV model:

- simulates discharge and groundwater recharge in high temporal and spatial resolution
- parameter regionalization using catchment attributes
- can integrate baseflow from a groundwater model

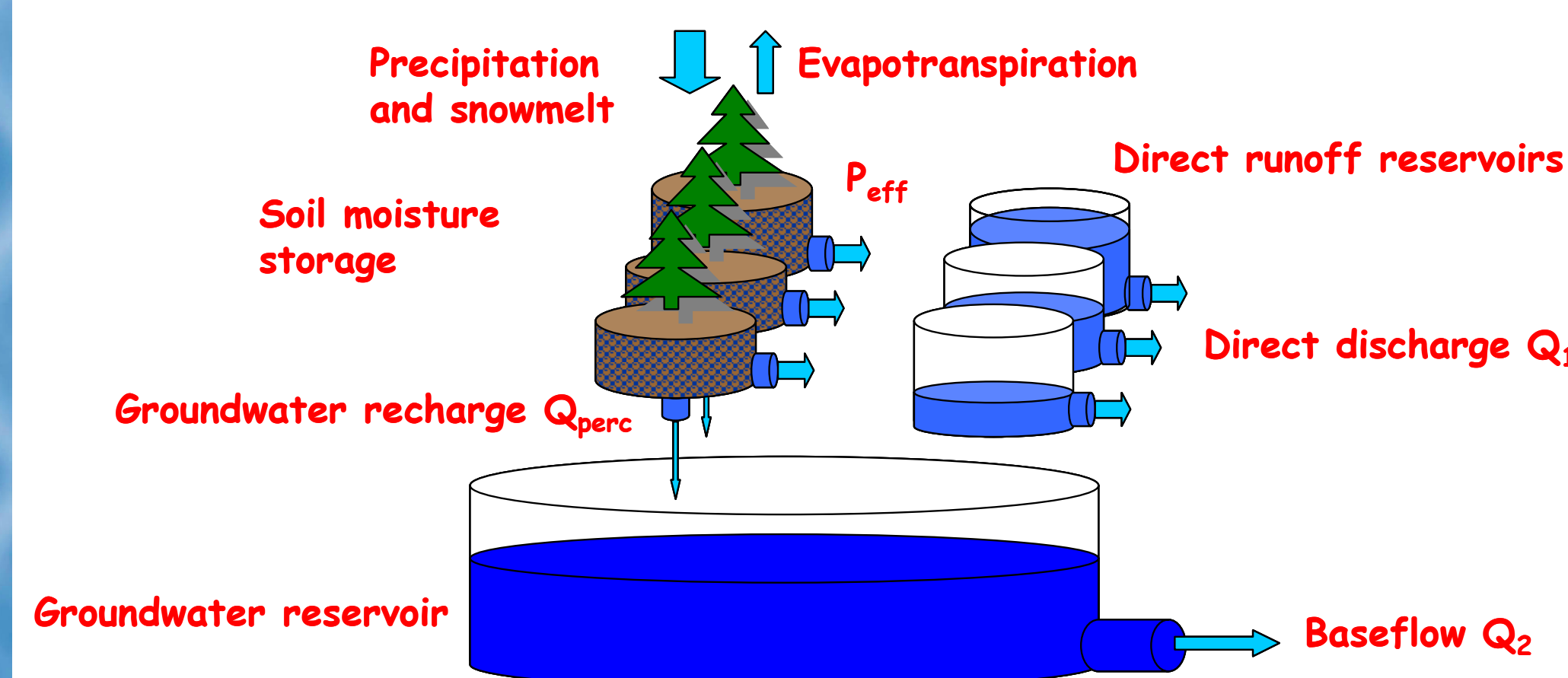


Fig. 3: Structure of the distributed HBV model

Regionalization using a combination of two conditions

Lipschitz: $|p_i - p_j| \leq \sum_{k=1}^L |c_{ki} - c_{kj}| \cdot K_k$

Monotony: if $(c_{ki} \leq c_{kj})$ for all k then $p_i \leq p_j$

p : model parameter, i, j : raster cells, c_k : cell properties

Tab. 2: Land use in the Ouémé basin [km²]

| | 2003 | Sc. A | Sc. B |
|-------------|--------|--------|--------|
| Forest | 9 510 | 5 308 | 3 058 |
| Savanna | 19 350 | 10 799 | 6 222 |
| Fields | 16 303 | 25 893 | 35 005 |
| Plantations | 1 349 | 3 982 | 2 277 |
| Settlement | 281 | 960 | 865 |

Fig. 4: Location and topography of the Ouémé basin in Benin and the outlet at the gauge Bonou

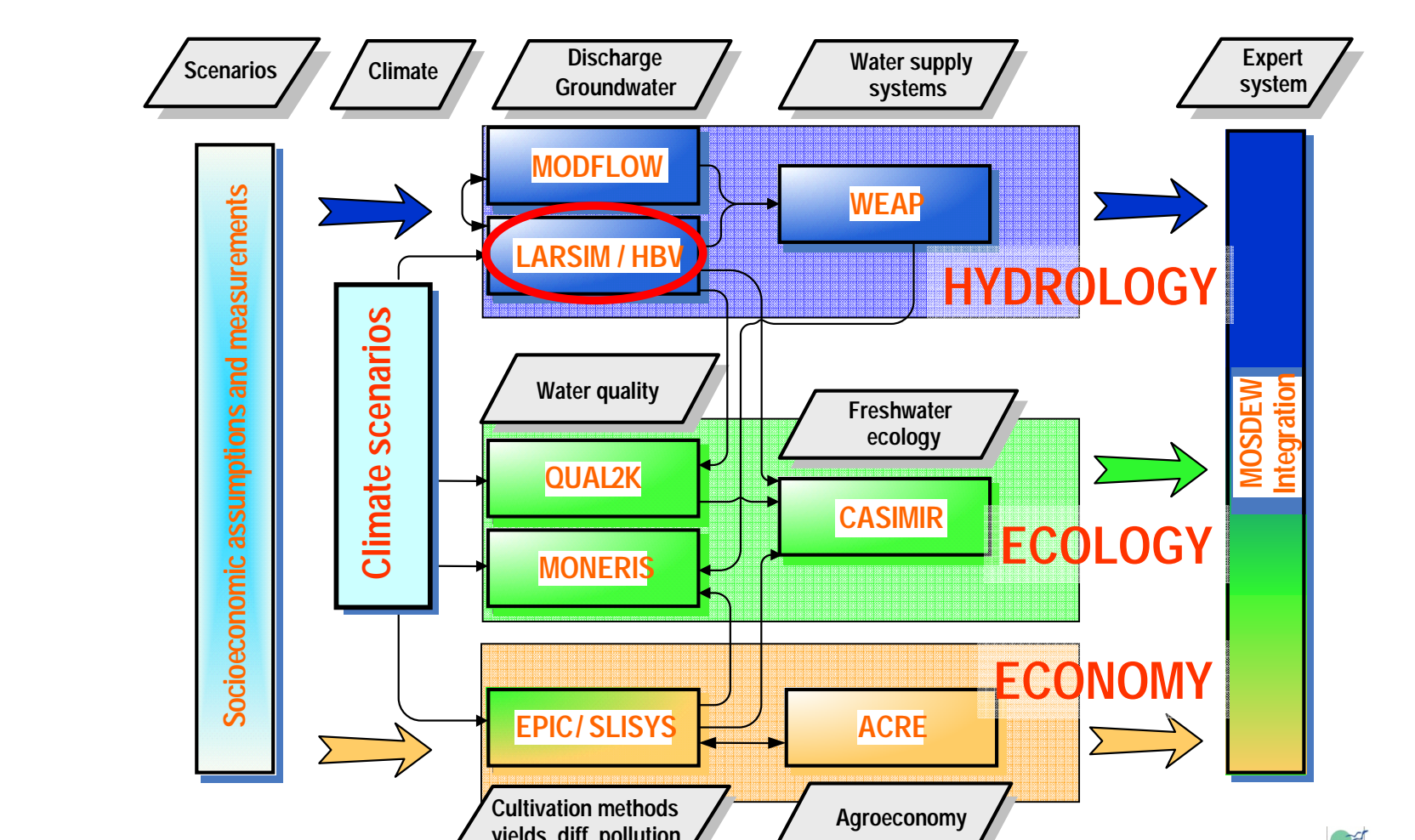
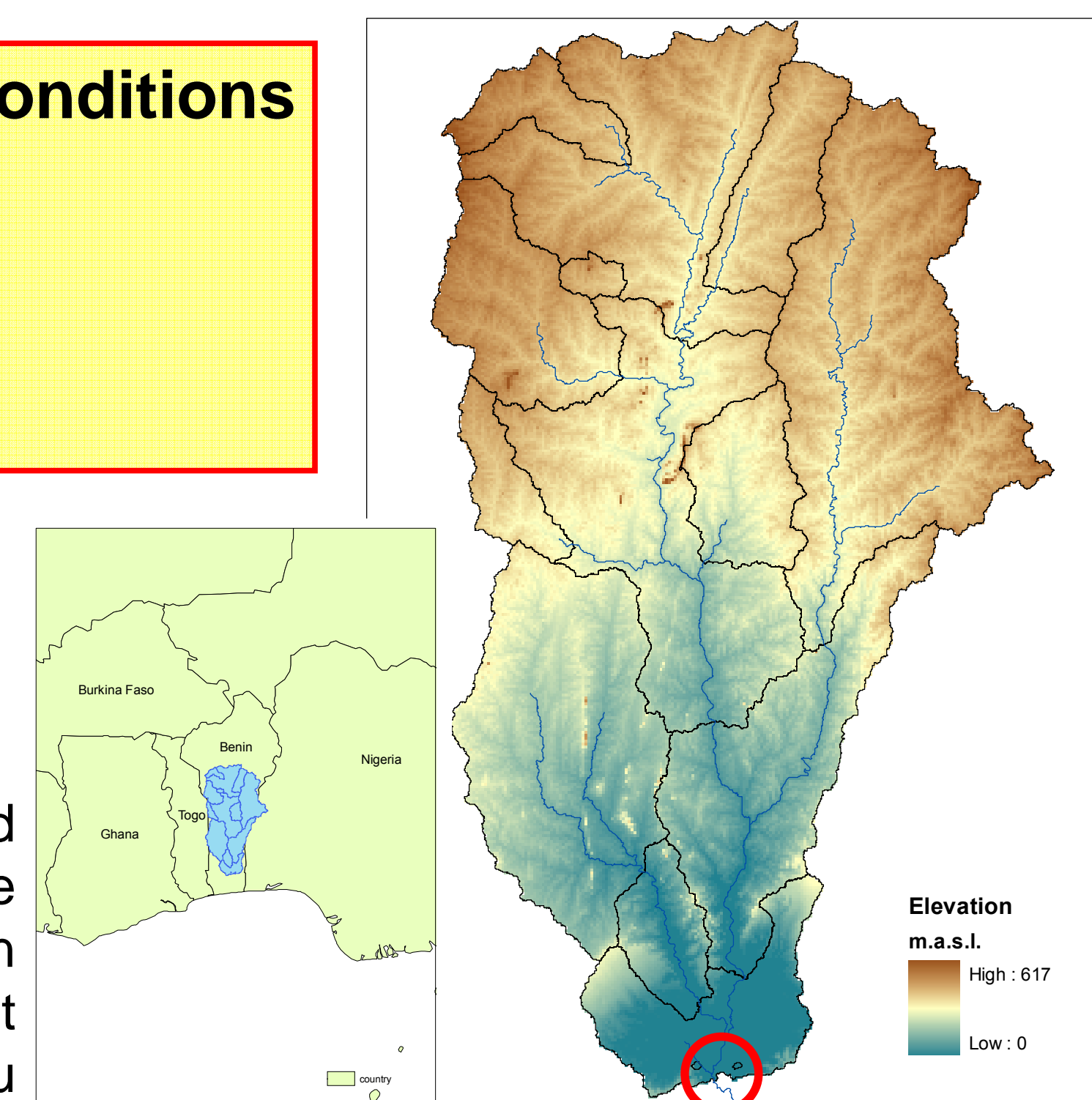


Fig. 2: Structure of the integrated regional model

| Parameter | Regionalized by | Regression type |
|------------|---|-----------------|
| β | Hydraulic conductivity upper soil layer, permanent wilting point | Logistic |
| k_{perc} | Log (bedrock hydraulic conductivity), hydraulic conductivity lower soil layer | Logistic |
| k_1 | Flow time, land use | Linear |
| α | Land use, field capacity | Logistic |
| k_2 | Log (bedrock hydraulic conductivity), area | Linear |

Tab. 1: Regionalized parameters of the HBV model



3. Climate change scenarios

A stochastic weather generator based on the emission scenarios A2 and B2 for 2001 to 2031 was used to generate high resolution precipitation and temperature data. Compared to a control run both climate scenarios show an increase in temperature. Precipitation increases in the North but decreases in the South during the rainy season. The climate scenarios are still affected by a large uncertainty so results must be used with caution.

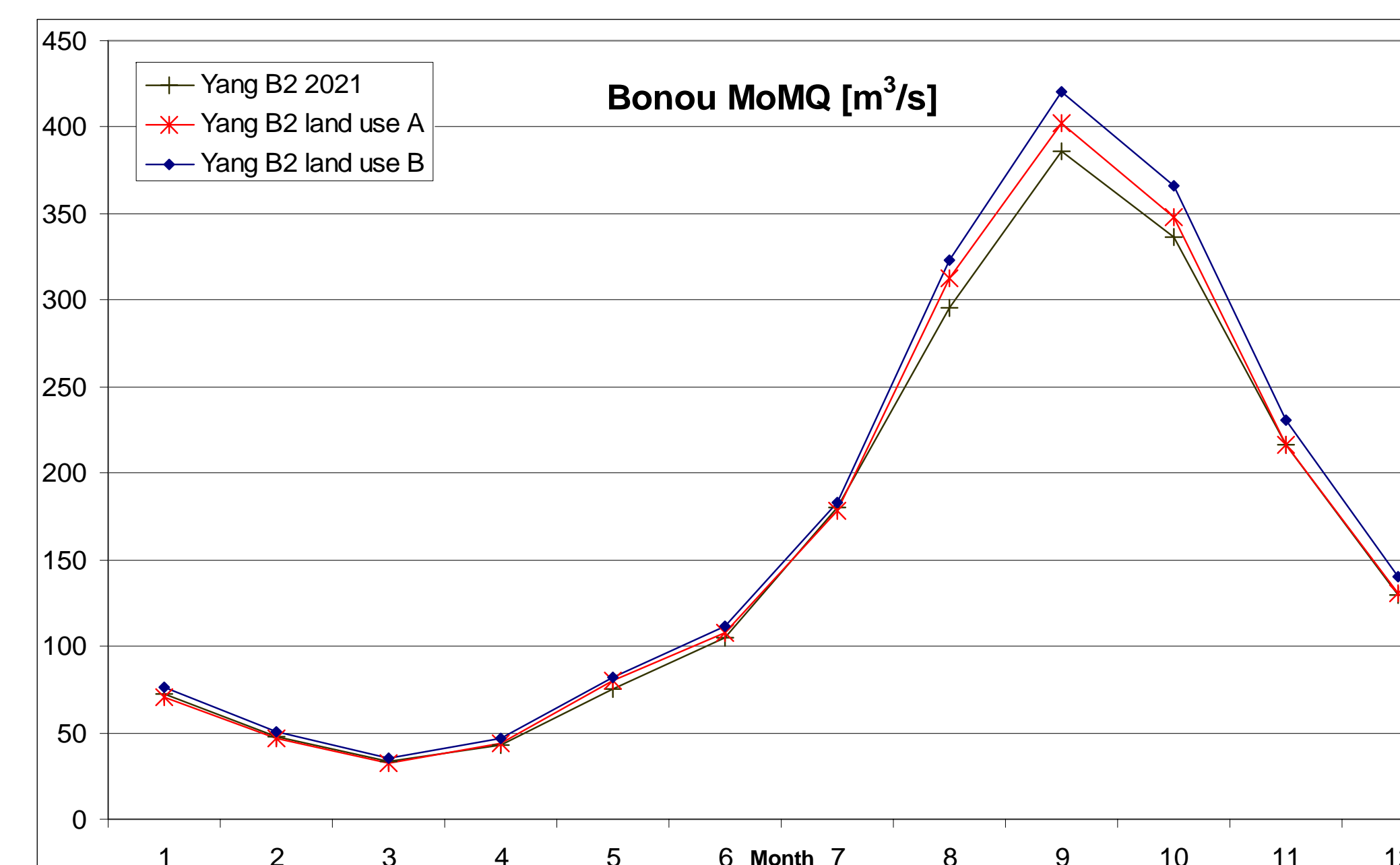


Fig. 6: Monthly mean discharge land use change scenarios

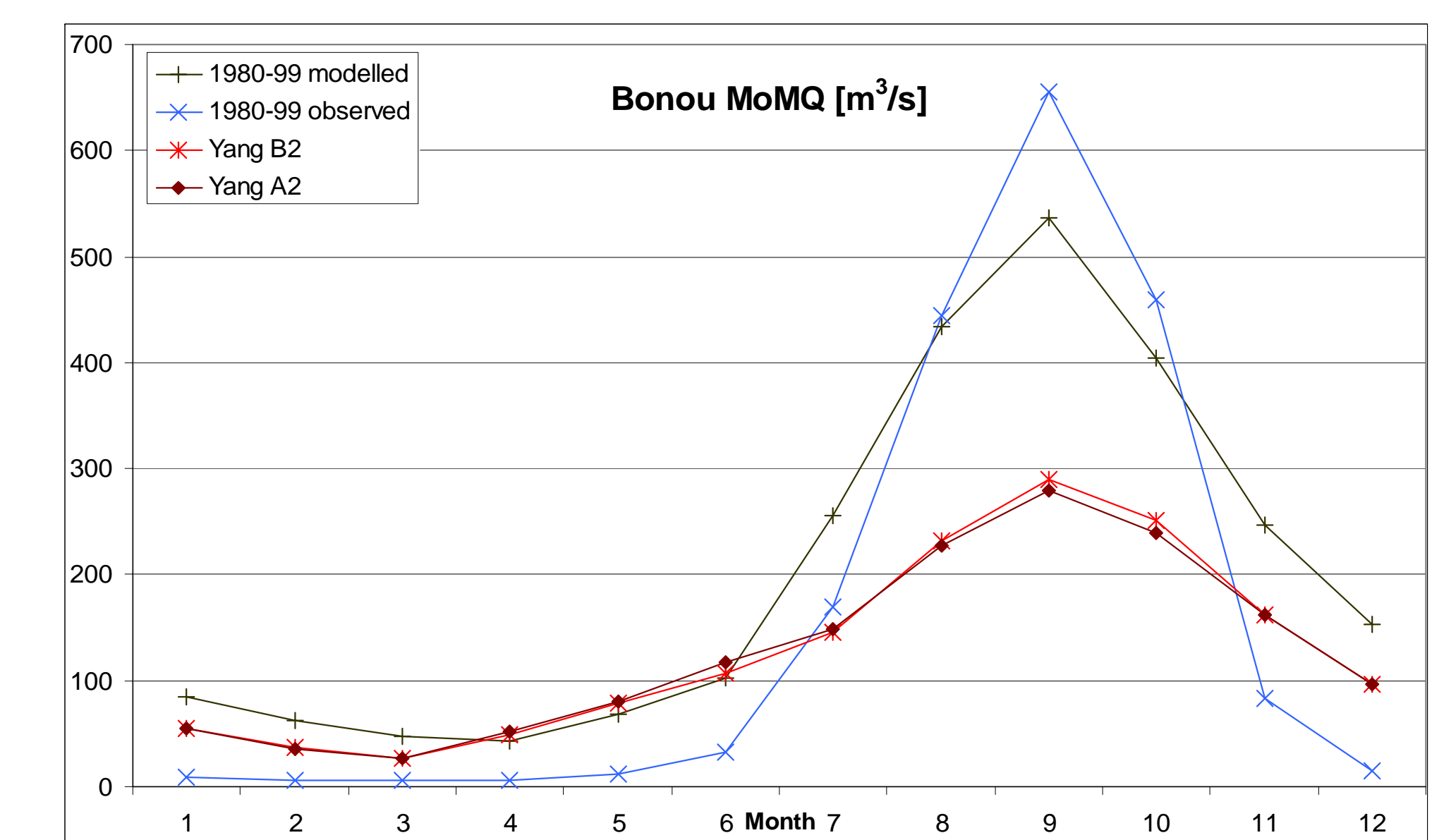
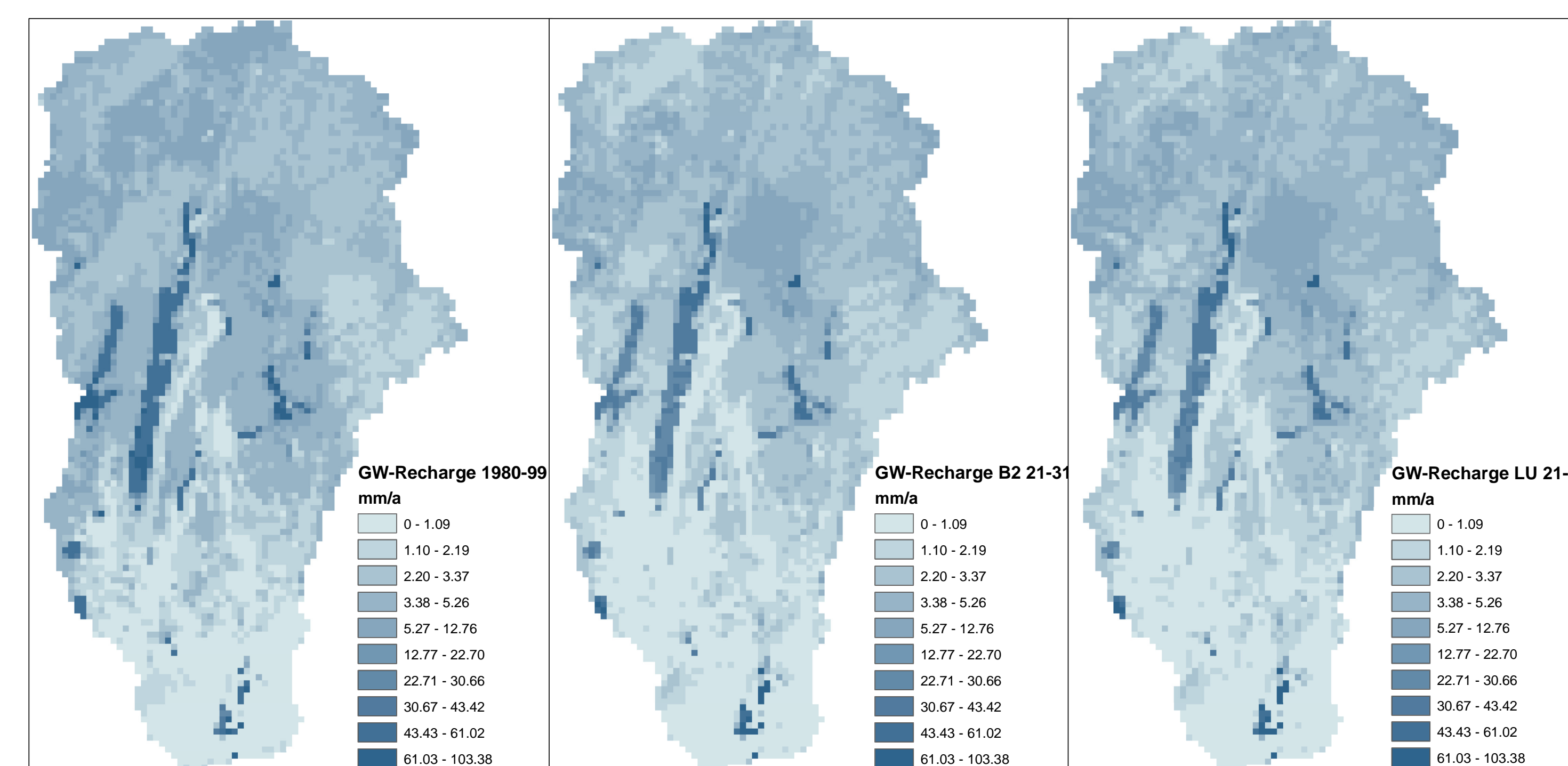


Fig. 5: Monthly mean discharge climate change scenarios

4. Land use change scenarios

- A: 3.2% population growth per year, strong economic development, controlled urbanisation
- B: 3.5% population growth per year, weak national economy, uncontrolled development of settlements and agricultural area

Both scenarios show a small increase in surface runoff from sealed areas and fields (2.4% and 7.5%). Soil moisture and groundwater recharge also increase by reduced evapotranspiration.



Conclusions:

- Integrated models can assist in estimating climate and land use change impacts on water resources
- Climate change could aggravate water scarcity in Benin

Fig. 7: Maps of mean annual groundwater recharge

| | 1980-99 | 2001-2031 | 2021-2031 | Land use A | Land use B |
|------------------|---------|-----------|-----------|------------|------------|
| Discharge [m³/s] | 202.95 | 126.50 | 157.14 | 164.12 | 172.23 |
| GW-Recharge [mm] | 5.6 | 3.4 | 4.3 | 4.5 | 4.7 |

J. Göttinger, J. Jagelke, R. Barthel and A. Bárdossy: Integration of water balance models in RIVERTWIN, in print, Advances in Geosciences

J. Göttinger and A. Bárdossy: Comparison of four regionalisation methods for a distributed hydrological model, in print, Journal of Hydrology

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